Audio/Modem Hardware Scalability in AC ’97/AMR-based Platforms

revision 1.0

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1. Introduction

This paper is targeted at IHVs and OEMs who have detailed working knowledge of PC audio and modem architecture. It is also recommended that the reader be familiar with the Audio Codec '97 Component and Audio/Modem Riser (AMR) Specifications, jointly developed by Intel and the industry, and available on the Intel Web server at http://developer.intel.com/pc-supp/platform/ac97/

The release of Audio Codec '97 Revision 2.1 (AC '97), and the Audio/Modem Riser (AMR) Specification Revision 1.01 has created new opportunities for reducing PC platform cost for the audio and modem subsystems. In the past the audio and modem subsystems were, almost exclusively, separate add-in cards. AC '97 R2.1 defines a standard way for combining the two subsystems, which ultimately brings down their collective cost. With the addition of the AMR specification these combined subsystems can now be integrated onto the motherboard yielding even further cost savings.

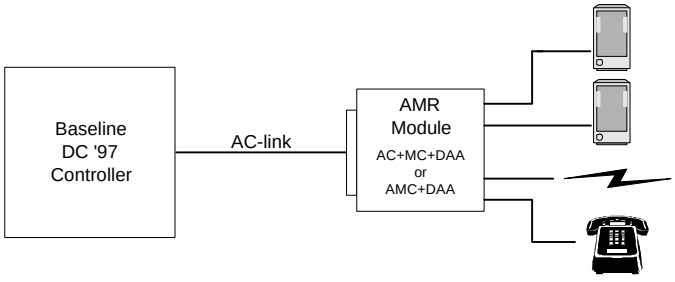
While arguably enabling the lowest cost audio/modem solutions for the basic PC market segment, the standard physical partitioning defined by the AMR specification also addresses other problems that had previously presented hurdles to motherboard-integrated audio and modem. Poor audio quality (i.e., signal-to-noise ratio) relating to soldering an audio DAC directly onto an electrically noisy motherboard are addressed with the better isolation that an AMR module affords an audio codec. On the modem side, long calendar delays associated with the homologation/certification of the analog modem electronics has dissuaded motherboard designers from integrating the modem subsystem onto the motherboard. AMR-based modems physically partition all of the "certifiable" electronics up on the riser module thereby de-coupling any of the certification delays from the introduction of the motherboard.

In addition to addressing cost and technical issues, AC '97/AMR-based motherboard solutions also enable robust, cost-effective hardware scalability. AMR enhances an OEM's freedom to choose flexibly between different audio and modem vendors (Cross-Vendor Flexibility)[1], while also preserving the popular Build-to-Order[2] system integration model.

This paper describes how beginning with a baseline AC '97/AMR configuration, the audio and modem subsystems can scale through hardware, while preserving the Build-to-Order and Cross-Vendor Flexibility models.

2. Baseline Audio/Modem Configuration

The following figure depicts a typical baseline AC '97/AMR configuration.



[1] "Cross-vendor flexibility" ensures that audio solutions from Vendor A can coexist with modem solutions from Vendor B for any combination of baseline and accelerated solutions.

[2] The Build-to-Order system integration model ensures that an OEM has the ability to select any upgrade solution at system integration time (i.e., just prior to shipment of the system).

The baseline audio/modem controller and AMR connector are soldered directly onto the motherboard. In this example, the baseline controller supports two channels of audio and a single line POTS modem[3]. The supporting AMR module consists of either separate codecs for audio and modem combined with a modem DAA, or a single combined audio plus modem (AMC) codec along with a modem DAA. The lowest cost baseline AMR solution would arguably be the AMC combined codec configuration.

3. Audio/Modem Scalability Models

Hardware scalability can be accomplished in one of two ways. Hardware accelerated controllers can be either soldered onto the motherboard or plugged into an expansion slot.

Motherboard-integrated controllers that support the serial protocol and electrical characteristics of the AC '97 Revision 2.1 AC-link, in combination with AMR's flexible modularity, can deliver a range of scalable motherboard solutions that may reuse the baseline's analog I/O circuitry (i.e., the AMR module).

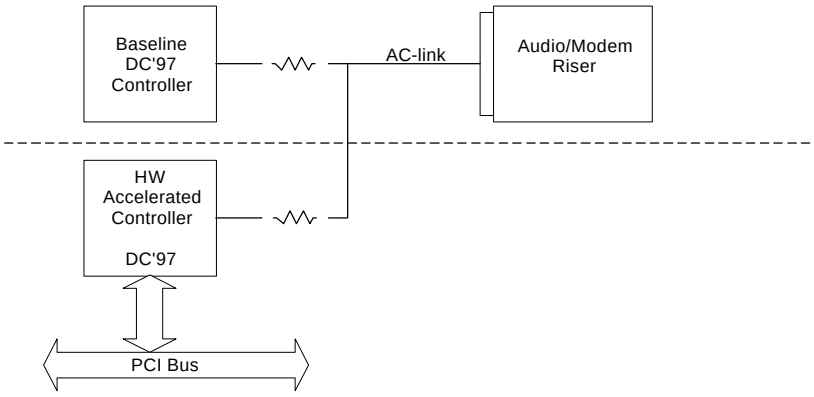
Alternatively, fully standalone hardware accelerated solutions (including analog I/O) can be integrated into the system via industry standard expansion such as by plugging into a PCI slot.

In a previous AC '97 whitepaper titled "Hardware Acceleration Models and Re-direction of Audio Streams" (available at: http://developer.intel.com/pc-supp/platform/ac97/wp/hw_acc.htm), "in-line", and "multi-trip" hardware acceleration models were discussed. This paper deals only with the preferred "in-line" acceleration model.

The following sections describe ways in which the audio and modem subsystems can be scaled in a platform that supports an AC '97/AMR interface.

3.1. Motherboard-Integrated Hardware Scalability

A motherboard manufacturer can offer a scalable range of motherboard audio and modem solutions by making provisions for an optional accelerated controller at motherboard design time. The following figure illustrates this.



At system integration time, a motherboard is employed with or without the HW accelerated controller stuffed. In the accelerated case, the AC-link is disconnected from the baseline controller (which is either

[3] AC '97 Revision 2.1's AC-link infrastructure supports up to six channels of audio and two POTS modem lines.

physically removed or as an alternative, logically hidden from the system software) and connected to the accelerated controller.

Advantages:

- ***Low Cost; Cost optimized for specialized OEM products***
- ***Can reuse the baseline platform's analog I/O***

This motherboard-integrated approach enables lower cost than could be achieved with, for example, a PCI add-in. Cost savings can be realized by eliminating the need for a separate PCB, and also by reusing the baseline platform's analog I/O circuitry (AMR module).

Furthermore, an OEM may decide that, for a given line of system products, they only require a single source for accelerated solutions. In this case motherboard-integrated scalability may offer the cost optimum solution.

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Disadvantages:

- ***Build-to-Order Model is not supported***

A hardware accelerated controller must be selected at motherboard design time with this approach. Therefore, this approach does not enable an OEM to flexibly choose an upgrade option at system integration time. The motherboard upgrade path has been locked into the vendor/product choice that was made when the motherboard was laid out.

Essentially, an OEM would be required to support a unique motherboard layout for each vendor's HW accelerated controller they want to offer. An OEM would also have to maintain an additional motherboard SKU in support of baseline audio/modem configurations.

- ***Cross-Vendor Flexibility is not supported***

Due to the "either/or" relationship of the baseline controller and the accelerated controller, in a non-baseline system configuration the accelerated controller must be responsible for mastering the AC-link for both audio and modem subsystems (if both are present).

Take the example case where a baseline platform supports soft audio from Vendor X and soft modem from Vendor Y. If either audio or modem is upgraded via a hardware accelerated controller, then the other non-accelerated subsystem must also be supported by the same controller. Therefore this approach precludes Cross-Vendor flexibility in all but the most basic (soft audio with soft modem) configuration.

3.2. Platform "Hybrid" Approach to Audio/Modem HW Scalability

While a fully motherboard-integrated approach for audio/modem scalability may not be suitable for some applications, alternatively a more conservative hybrid approach can be applied that comprehends the Build-to-Order system integration model, while also enabling Cross-Vendor flexibility.

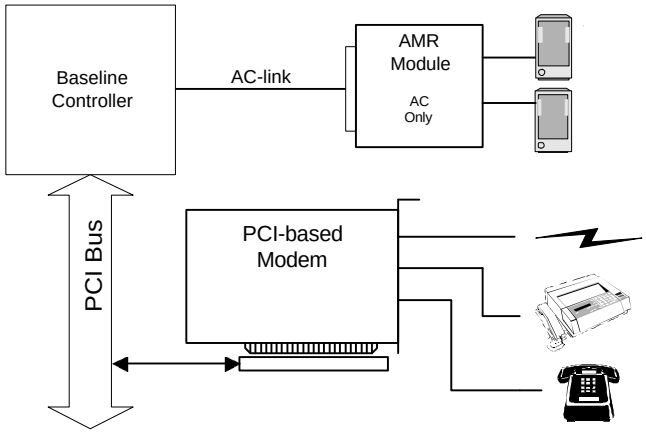
This new hybrid approach is one in which, using a single motherboard layout, a scalable range of platform solutions is possible by employing the right combination of motherboard AMR module and add-in adapter. This cost efficient, scalable range of solutions with a single motherboard layout is possible because of the motherboard modularity that an AMR connector introduces.

By selecting the appropriate hybrid combination of motherboard AMR module along with the desired PCI add-in adapter, scalability can be achieved in a manner that supports both Build-to-Order and Cross-Vendor Flexibility.

The following subsections provide examples of the full range of audio/modem scalability available with the hybrid approach, all stemming from the same motherboard layout that is used in the baseline configuration.

3.2.1. Host-based (soft) Audio with Hardware Accelerated Modem

The following figure shows a typical system configuration where baseline audio is employed along with a hardware accelerated two-line modem.



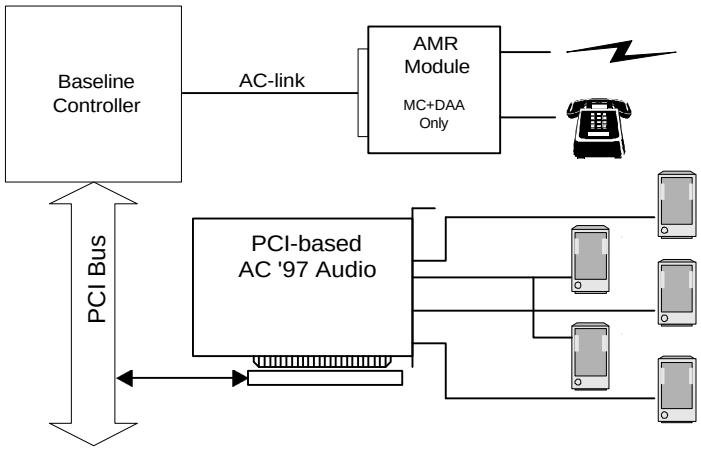
The AMR module selected for this platform solution supports audio only (AC '97 audio codec only), and bears essentially no baseline modem cost burden[4]. The AMR module, its associated audio driver, along with the PCI modem and its driver can be integrated in a Build-to-Order fashion with freedom of choice with respect to their vendors[5].

[4] Assuming that the baseline controller supports both soft audio and soft modem pipes, there is a small cost overhead associated with the unused gates that would have been used for the modem interface's DMA functionality.

[5] Motherboard BIOS must comprehend (possibly in a look-up table) the Subsystem ID and Subsystem Vendor ID for each supported AMR module-based solution in order to correctly identify it for the operating system.

3.2.2. Host-based (soft) Modem with Hardware Accelerated Audio

The following figure shows a typical system configuration where baseline modem is employed along with a hardware accelerated four-channel audio solution.



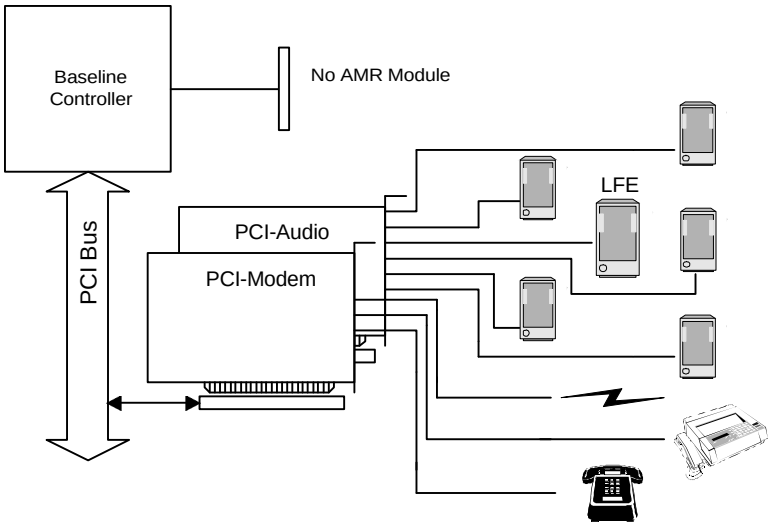
The AMR module selected for this platform solution supports modem only (MC '97 modem codec plus DAA only), and bears essentially no baseline audio cost burden[6]. The AMR module, its associated modem software stack, along with the PCI audio card/driver can be integrated in a Build-to-Order fashion with freedom of choice with respect to their vendors[7].

[6] Assuming that the baseline controller supports both soft audio and soft modem, there is a small cost overhead associated with the unused integrated audio pipe DMA logic.

[7] Motherboard BIOS must comprehend (possibly in a look-up table) the Subsystem ID and Subsystem Vendor ID for each supported AMR module-based solution to correctly identify it for the operating system.

3.2.3. Hardware Accelerated Audio and Modem

The following figure shows a typical system configuration where the baseline controller and AMR interface are not utilized.



This configuration, consisting of six-channel audio and a two-line modem, integrates both subsystems into the platform via separate PCI add-in cards.

The associated baseline audio/modem overhead can be broken down into the unused pins and gates of the baseline controller, and a vacant AMR connector.

4. Conclusions

Systems that incorporate motherboard support for an AC '97/AMR interface are not only capable of achieving the lowest possible cost for basic PC audio and modem, but have also introduced increased motherboard flexibility enabling robust, cost effective scalability.

Motherboard-Integrated Approach

This method enables a cost optimized audio/modem HW scalability solution for system manufacturers who have specific requirements that do not include support for a Build-to-Order integration model, or Cross-Vendor selection flexibility.

Hybrid Approach

By combining an AMR-supported motherboard's flexibility with standard forms of peripheral expansion, an OEM can offer a range of scalable solutions all stemming from a single motherboard layout.

In all but the highest end (hardware accelerated audio and modem) configuration, the baseline cost overhead is negligible because an AMR module is utilized.

For the high-end configuration, the cost burden relating to the unused baseline audio/modem controller and AMR connector should be weighed against the alternative costs that would be associated with maintaining multiple motherboard SKUs. A cost conscious OEM may determine that maintaining two motherboard SKUs may be manageable and more cost efficient for a given line of products. In this case the high-end configurations would employ the motherboard SKU that did not stuff the baseline audio/modem controller[8] and/or the AMR connector thereby reducing or eliminating the baseline cost overhead for high-end configurations.

[8] If not used for other functions in the platform besides baseline audio and modem control.